5 SENSITIVITY ANALYSIS

Sensitivity analysis is the process of varying model input parameters and evaluating how model output changes with such variations. The significance of model sensitivity analysis is two-fold: (1) it provides information on the behavior of model output to input parameters which, in turn, can be used in model calibration; and (2) it gives insight in establishing priorities related to future data collection efforts. Sensitivity analysis is not the same as uncertainty analysis. Sensitivity analysis indicates the importance of the input parameters. On the other hand, uncertainty analysis attempts to quantify the confidence limits in model output as a function of uncertainties in model input parameters. This section deals with sensitivity analysis as applied to the model and the next section will discuss model uncertainty analysis at a similar level of detail. This chapter is entirely based on Trimble (1995a).

5.1 METHODOLOGY

The sensitivity of the output variables to variations in input parameters is estimated by the traditional approach of varying one parameter at a time. A sensitivity matrix is set up that summarizes the response at each observation point to changes in individual parameters. Model response is expressed in terms of simulated nodal stages or canal flows within the model domain. The following input parameters are systematically varied in order to analyze model output sensitivity:

1. Surface roughness coefficient for overland flow;
2. Reference ET for wetland, coastal and EAA areas;
3. Groundwater hydraulic conductivity;
4. Seepage coefficient;
5. Detention parameter;
6. Canal-groundwater hydraulic conductivity;
7. Canal-overland flow surface roughness; and
8. Weir discharge coefficient.

Since the ranges of acceptable parameter values to be used for sensitivity analysis are not available in the literature, parameters were varied over a range for which the model calibration was assumed to remain valid (Loucks and Stedinger, 1994). Acceptable ranges of variation for some input parameters based on a preliminary uncertainty analysis are suggested by Trimble (1994) and are presented in Table 5.1.1.

A sensitivity or influence matrix is set up that summarizes the response at selected observation points to changes in individual parameters. Each element of this matrix can be represented by the following relationship (Trimble, 1995a):

$$\alpha_{ij} = \frac{\partial y_j}{\partial x_i} \approx \frac{y_j^c - y_j^o}{\Delta x_i} \quad \forall \quad i = 1,...n; \; j = 1,...m \tag{5.1.1}$$

where:

α_{ij} = sensitivity of the j th simulated output/performance value to the i th parameter;
y_j = j th model simulated output/performance value;
x_i = i th parameter being tested;
m = number of observations being simulated;
n = number of parameters being evaluated;
o = simulated value with the original calibrated parameter; and
c = simulated value when a parameter is changed by an incremental value Δx_i.

Table 5.1.1 Acceptable Range of Variation for Parameters/Physical Process Expressed in Terms of Calibrated Values

Parameter/Process	**Percent Change from Calibrated Values**
Manning's *n*	Up to 25%
evapotranspiration	Up to 4%
canal-groundwater hydraulic conductivity	Up to 20%
aquifer permeability	Up to 10%
levee seepage	Up to 10%

Next, a matrix factorization technique (single-value decomposition or SVD) is applied to the sensitivity matrix in order to: (1) understand the relationships between the parameters; and (2) isolate groups of parameters that are dependent on one another. The method leads to the determination of the parameter covariance matrix which is also known as the uncertainty matrix. The uncertainty matrix is discussed further in Chap. 6.